Data Quality Management Program

for the

Collection of Pavement Condition

NEBRASKA

Good Life. Great Journey.

DEPARTMENT OF TRANSPORTATION

Prepared by

Materials & Research Division
Lincoln, Nebraska
dot.nebraska.gov

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Disclaimer

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Document Change Control

The following is the document control for revisions to this document.

Version No	Date of Issue	Author(s)	Brief Description of Change

Definitions

The following are definitions of terms, abbreviations, and acronyms used in this document.

Term	Definition
AASHTO	American Association of State Highway and Transportation Officials
ASTM	American Society of Testing and Materials
DCV	Data Collection Vehicle
DMI	Distance Measuring Instrument
GPS	Global Positioning Systems
HPMS	Highway Performance Monitoring System
IP	Inertial Profiler
IRI	International Roughness Index
PMS	Pavement Management System
QA	Quality Assurance
QC	Quality Control
QM	Quality Management
EOY	End of Year

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SECTION 1 INTRODUCTION

1.1 Overview

Documenting the Nebraska Department of Roads (NDOT) data quality management (QM) program for pavement condition data collection will aid in assuring reliable, accurate, and complete data. This document describes the processes and procedures used for ensuring the desired outcomes noted above.

This QM plan institutes and documents the data quality requirements for all deliverables. The framework below provides a brief description of each section.

Section 2: Deliverables, Protocols, and Quality Standards - The data collection deliverables subject to quality review, protocols used to collect, and quality standards that are measures used to determine a successful outcome for a deliverable. Deliverables are evaluated against these criteria before they are formally approved. NDOT has specified realistic and attainable quality standards for each data item collected.

Section 3: Quality Control (QC) - QC includes those activities performed to assess and adjust production processes to obtain the desired level of quality data.

Section 4: Acceptance - The acceptance testing that will be used to determine if quality criteria are met and corrective actions that will be taken for any deliverables not meeting criteria.

Section 5: Quality Team Roles and Responsibilities - The QM-related responsibilities of the data collection team.

Section 6: Quality Reporting Plan - The documentation of all QM activities including quality standards, QC, acceptance, and corrective actions and the format of the final QM report.

Section 8: Acceptance of QM Plan - Signature page for acceptance of the QM Plan.

1.2 How Data is Collected

The Nebraska Department of Transportation (NDOT) owns two pavement data collection vehicles (DCV) to conduct semi-automated pavement condition surveys. Supplemental pavement condition distress surveying is done manually using video images or by in the field visual survey.

NDOT is in the process of transitioning to automated distress detection, which will replace manual in the field visual surveys with the exception of verification. Automating this process will provide repeatability, eliminate subjectivity, increase safety, reduce costs, and provide more time for verification and quality control.

1.3 When Data is Collected

NDOT begins its annual DCV collection around the first of April to insure a good sun angle for images. This of course depends on the weather, as surveying is not performed on pavements when they are wet or there is snow on the shoulders or right-of-way. The goal for the completion of the non-interstate state highways is August 15th. NDOT uses the month of

September to collect the Interstates and locally owned National Highway System (NHS). Visual surveys are accomplished throughout the entire year, weather permitting.

1.4 Where Data is Collected

NDOT collects pavement condition data on approximately 10,000 centerline miles of state highways and approximately 135 centerline miles of locally owned roadways on the NHS. Other pavement condition collections may be performed as necessary for ramps, recreation roads, and detour routes. NDOT has a two-year cycle in which the entire highway system is collected. For two-lane highways, one direction is collected in alternating directions each year. For multi-lane highways and interstates, both directions are collected each year in the driving lane. NDOT collects condition metrics from the DCV at one-tenth mile increments and performs visual distress surveys at each one-mile reference point. Additional visual surveys are taken at the following control points:

- Beginning of route
- Surface type change
- Beginning of change from 2-lane to multi-lane facilities
- Corporate boundaries
- District boundaries

1.5 What Data is Collected

The DCV collects digital images on and along highways and 3D-sensor data for measuring roughness, rutting, and faulting. Additional information available from the DCV includes a 3D surface model, cross-slopes, coordinates, and horizontal/vertical alignments. See Table 1.1.

Data collected from visual surveys include the severity (absent, low, medium, high, extreme) and extent (absent, trace, occasional, frequent, extensive, complete) of the distress types shown in the Table 1.1. More information on visual surveys can be found in NDOT's Surface Distress Survey Manual[1].

[1] The NDOT surface distress survey manual can be found at: https://dot.nebraska.gov/business-center/materials/

Table 1.1 Condition Data Items Collected

General Data	Bituminous, Asphalt and Composite Pavements	Jointed Concrete Pavements and Concrete Overlays
Data Collection Vehicle • Location (highway, RP, offset, length, latitude & longitude determined by GPS coordinates) • Perspective, ROW, rear, and rear downward surface Images • Optional Geometric Data (horizontal and vertical curves, cross-slope, super-elevation)	*Data Collection Vehicle* • IRI • Rutting *Visual Survey's* • Longitudinal Cracking • Transverse Cracking • Grid/Block Cracking • Alligator Cracking • Raveling/ Weathering • Bituminous Patching • Failures • Excess Asphalt	*Data Collection Vehicle* • IRI • Faulting *Visual Survey's* • Corner Breaks • Longitudinal Cracking • Transverse Cracking • Longitudinal Joint Spalling • Transverse Joint Spalling • Bituminous Patching • Joint Repairs • Panel Repairs • Joint Seals • Crack Seals

SECTION 2 DELIVERABLES, PROTOCOLS, AND QUALITY STANDARDS

2.1 DCV Deliverables, Protocols, and Quality Standards

Quality standards define, when applicable, the resolution, accuracy, repeatability or other standards that will be used to determine the minimum characteristics of each deliverable from the DCV. See table 2.1 and Section 4 for the Acceptance Testing Plan.

Table 2.1 DCV Deliverables, Protocols, and Quality Standards

Deliverable	Protocols	Resolution	Accuracy (compared to reference value)	Repeatability (for three repeat runs)
Longitudinal Profile	AASHTO M 328-10, AASHTO PP 70-10, AASHTO R 56-14, ASTM E950	1 in/mile	+/- 5%	+/- 5%
IRI (left, right, and average)	AASHTO PP 37-04, AASHTO R 43-07,	1 in/mile	+/- 5%	+/- 5%
Rut Depth (average and maximum)	AASHTO PP 69-10, AASHTO R 48-10, ASTM E1703	0.254 mm	+/- 0.4826 mm	1.524 mm
Faulting (average)	AASHTO R 36-12	0.254 mm	1.524 mm	1.524 mm
Distress Identification and Rating *(for future ratings)*	AASHTO PP 67-10, AASHTO PP 68-10,	Varies	+/- 20 percent	N/A
GPS (latitude and longitude)	N/A	Submeter (static)	Submeter (static)	N/A
Perspective, ROW, and Rear Roadway Images	N/A	2500 X 2000 per camera	Signs legible, proper exposure and color balance	N/A
Rear Downward Pavement Images	N/A	N/A	2 mm cracking visible and detected	N/A

2.2 Visual Survey Deliverables, Protocols, and Quality Standards

Quality standards define, when applicable, accuracy, repeatability or other standards that will be used to determine the minimum characteristics of each deliverable from the visual survey. See Table 2.2, Table 2.3, and Section 4 for the Acceptance Testing Plan. Protocols can be found in the NDOT Surface Distress Survey Manual[2]

Table 2.2 Visual Survey Deliverables and Standards for Bituminous/Asphalt/Composite

Bituminous/Asphalt/Composite				
Distress Type	**Severity**	**Standard**	**Extent**	**Standard**
Longitudinal Cracking – Centerline Wheel path Between wheel path Edge	Absent Low Moderate High	0” – 1/4” 1/4” – 1/2” > 1/2”	Absent Trace Occasional Frequent Extensive Complete	% of area < 10% 10% - 30% 30% - 50% 50%-80% > 80%
Grid Block Cracking	Absent Low Moderate High Extreme	0” – 1/4” 1/4” – 1/2” 1/2” – 2” > 2”	Absent Trace Occasional Frequent Extensive Complete	% of area < 10% 10% - 30% 30% - 50% 50%-80% > 80%
Transverse Cracking	Absent Low Moderate High Extreme	0” – 1/4” 1/4” – 1/2” 1/2” – 2” > 2”	Absent Trace Occasional Frequent Extensive Complete	TC spacing >500’ 200’ – 500’ 100’ – 200’ 50’ – 100’ <50’
Alligator Cracking – Wheel Path Centerline Between Wheel Path	Absent Low Moderate High	0” – 1/8” 1/8” – 1/4” > 1/4”	Absent Trace Occasional Frequent Extensive Complete	% of area < 10% 10% - 30% 30% - 50% 50%-80% > 80%
Failures		Area > 2 Sq. Ft.	Absent Trace Occasional Frequent Extensive Complete	% of area < 10% 10% - 30% 30% - 50% 50%-80% > 80%

[2] The NDOT surface distress survey manual can be found at: https://dot.nebraska.gov/business-center/materials/

Table 2.3 Visual Survey Deliverables and Standards for Portland Cement Concrete

Portland Cement Concrete		
Distress Type	**Severity**	**Standard**
Joint Repairs	NA	% of joints repaired
Joint Severity	Absent Moderate High	Based on identified cracking, staining, or spalling of any joint
Joint Spalls	1 Sq. Ft. Min	% of joints spalled
Joint Seal	Good Poor or Absent	Absent or any failure is considered poor
Panel Surface		
Panel Cracking	Class I Class II	Hairline w/no horiz. or vert. displacement- % of panels Structural that results in horiz. or vert. displacement- % of panels
Panel Condition (Pattern Cracking)	Absent Low Moderate High	 Light staining Discoloration/staining w/random hairline cracking Staining w/interconnected pattern of cracking greater than hairline
Panel Spalls	1 Sq. Ft. Min	% of panels spalled
Panel Repairs	NA	% of panels repaired
Crack Seal	Good Poor or Absent	Absent or any failure is considered poor
Panel Crack Faulting	Absent Low Moderate High	0” – 1/8” 1/8” – 1/4” 1/4” – 1/2” > 1/2”

SECTION 3 QUALITY CONTROL

3.1 Quality Control Standards, Expectations, and Frequencies

Our primary focus of Quality Control (QC) is on data collection deliverables and processes. QC aims to monitor deliverables to verify that they are of acceptable quality, accurate, precise, and thoroughly complete. The following Table 3.1 identifies:

- Deliverables that will be tested for satisfactory quality level.
- Quality expectations for the deliverables.
- AASHTO Standards
- QC Activities to control and monitor the quality of the deliverables.

The frequencies and intervals of the QC Activities to be performed.

Table 3.1 Quality Control Standards, Expectations, and Frequencies

Deliverable	AASHTO Standards	Quality Expectations	QC Activity	Frequency/Interval
IRI, DMI	AASHTO PP37-04 AASHTO R 43-07	95 Percent Compliance With Standards	Equipment Configuration, Calibration, Verification	Pre-Collection (Annually) Collection (Monthly)
			Daily Equipment Checks and Monitor Real-Time	Daily
			Vendor Recommended Test Sections	Monthly / As Needed
			Inspect Uploaded Data Samples	Weekly
			Inspect Processed Data by Running Comparison Reports	Monthly/During Manual QC
			Final Data Review	Prior to EOY Database Freeze
Rut Depth, Faulting, GPS Coordinates, Longitudinal Grade	AASHTO R 36-12 AASHTO R 48-10 AASHTO R 56-14 AASHTO PP 70-10 AASHTO PP 69-10 AASHTO M 328-10 ASTM E950 ASTM E1703	95 Percent Compliance With Standards	Initial Equipment Configuration, Calibration, Verification	Pre-Collection (Calibration at time of equipment purchase/Pathways HQ)
			Daily Equipment Checks and Monitor Real-Time	Daily
			Control, Blind, or Verification Testing	Monthly / As Needed
			Inspect Uploaded Data Samples	Weekly
			Inspect Processed Data by Running Comparison Reports	Monthly/During Manual QC
			Final Data Review	Prior to EOY Database Freeze
Distress Rating *(for future ratings)*	AASHTO PP 67-10 AASHTO PP 68-10		Initial Rater Training	Pre-Collection (Annually)
			Breakdown of Distress Report created by Data Quality Manager	Monthly During Collection Season
			Final Data Review	Prior to EOY Database Freeze
Perspective, ROW, and Rear Roadway Images	N/A	Less than 2% of images collected missing and/or un-usable due to obstructions or improper light saturation. No more than 5 consecutive images missing.	Startup Checks, Real-Time Monitoring, and Field Review	Daily
			Uploaded Samples Review	Weekly
			First & Last Image Check / Final Review	Prior to Processing

3.2 DCV Calibration and Verification

NDOT's DCV's are annually taken to the vendor's facility for IRI calibration and certification on asphalt. If the testing and certification for asphalt meets the requirements, then it meets certification requirements for PCC because it is using the same sensors. The DMI is also calibrated at this time. This is typically done in the Fall after the collection season is completed and in preparation of the next seasons collection.

The bounce and block tests will be performed on the DCV by NDOT employees. See the vendors documentation for test methodology details[3]. The following test steps will be taken:

- The block test is used to calibrate the wheel path lasers.
    - Must meet tolerance of +/- 0.005" of the block thickness being used for calibration.
    - If block test does not meet the tolerance of 0.003 ft., then it will be recalibrated.
- The bounce test is used to verify the proper function of the accelerometers with relation to the wheel path lasers.
- If NDOT employees cannot get the vehicle within tolerances, the vendor will be contacted for further instructions/recommendations to bring it within tolerance.

The DCV must have verifiable repeatability in its calibration and verification testing. The following apply:

- Must complete a minimum of 5 runs on asphalt pavement. The 5 runs must pass the following criteria:
    - The mean IRI of the test sections must come within the repeated average variance.
    - The distance of each run must be within 0.2% of the actual length of the test section using the DMI
- If the vehicle does meet these ranges, the following will be completed:
    - Perform the bounce test and block test again.
    - The vendor will be contacted for further instructions/recommendations.

[3] Contact NDOT for vendor documentation

Monthly verification is done on the DCV. The verification is performed at the beginning of the week before collection begins. The verification site is 1.5 miles long on asphalt, and is not scheduled for construction or maintenance so the condition stays constant during the 2-year collection cycle. The verification sites are used to verify the DMI, IRI, Faulting, and Rut Depth.

- The baseline for average IRI and average Rut Depth is established by taking the average of 5 initial runs, which are graphed. The graphs are not expected to be identical but should consistently follow the same shape.

- If the graphs are not consistent, the following will be completed:

    - An additional run is made of the verification site and graphed.

    - All monthly runs for the season will be graphed vs. time to confirm consistency in the data.

        - If graphs are still not consistent, the test site will be run with alternate equipment to confirm or refute the noted change.

Additional DCV Calibration

Any additional calibration comes as necessary. A few scenarios that would call for a recalibration are tire pressure change, wheel alignment and rotation, new tires, and any other work done to the vehicle that may affect the wheel path laser.

Initial QC Checks

When returning with collected data, drives are loaded into the networked blade server and data sets transferred, then the following initial QC checks will be performed:

- Within vendor software, run First/Last Image Check and verify any discrepancies.

- Verify all sensor data is complete by processing raw files for left and right IRI. If there are no errors and the data is not a null set or zeroes, the sensor data has been collected.

- Check for log file discrepancies.
  Run severity analysis and GPS Update start/end as required.

At the end of the pavement condition data collection season the following QC will be performed:

- Populate averages in the database by updating summary.

- Match .sec file line start/end times with collected data. Adjust sections that were over-collected in regards to distance of a section.

- Run Auto Class (crack classification) on all previously processed data.

- The vendor will be notified of any major discrepancies to determine if any changes need to be made to the automated crack detection and analysis software. (This is performed as part of the transition process to confirm the automated crack detection is in line with current visual surveys.)

3.3 Visual Surface Distress Survey Certification

Annually, the Highway Pavement Management Coordinator conducts training sessions on performing a surface distress survey. The scope of these training sessions are to provide the necessary preparation for the Distress Rating Team in order to correctly deliver a summary of the overall condition of the pavement in any area of the state.

The training sessions encompass the rating criteria for the analyses of bituminous/asphalt/composite pavements and Portland cement concrete. Each rater performs numerous individual surveys which are then critiqued by the team to provide feedback, reduce subjectivity, and build consistency. Once the Assistant Roadway Asset Management Engineer is satisfied that all raters are competent in the rating process, they are validated to complete the manual distress surveys. Survey training attendance documents are recorded and provided to the State Auditors during the GASB34 audit.

The raters begin each collection season with a database from the previous year's visual ratings. Starting with the previous ratings, allows the raters to confirm previous ratings and adjust the severities and extents, as necessary to identify deterioration, without having to re-enter all distress ratings. This provides additional QC and consistent ratings.

At the end of the pavement condition data collection season the following QC will be performed:

- Manual QC Checks for Distress Ratings:
    - 100% of the highway system will be manually scored, either by field or image rating, and compared to the automated analysis.
        - Any difference of 10 points or more between the previous year's Nebraska Serviceability Index (NSI) will be reviewed in detail. The NSI value is generated from DCV sensor data and visual surveys.
    - Distresses will be compared from year to year to flag any substantial differences from the previous year and checked against any current or encountered projects.
- Distresses that have large variations may be field verified.

SECTION 4 ACCEPTANCE

Establishing standardized acceptance methodologies is essential to ensuring accurate and repeatable data. Table 4.1 summarizes acceptance standard NDOT.

Table 4.1 Acceptance Standards

Deliverable	Acceptance Limits	Acceptance Testing & Frequency	Action if Criteria Not Met
IRI, DMI, Rut Depth, Faulting, GPS Coordinates, Longitudinal Grade	+/- 5% Accuracy from season baseline established through pre-season verification and monthly/weekly verifications.	Monthly testing of sensors. Daily inspection of data for suspect or inaccurate values.	Recalibration and possible recollection
Distress Rating	Any unusual severity based drop or raise of more than 10 NSI points dependent on other roadway variables.	Visual rating of distresses compared to prior year distress rating and unusual changes explained. Compared to crack detection software for possible future rollout.	Ratings adjustment as needed. Notes of construction or other obstacles.
Perspective, ROW, and Rear Roadway Images	Less than 2% of images collected missing and/or un-usable due to obstructions or improper light saturation. No more than 5 consecutive images missing.	Active monitoring of cameras during collection. Frequent adjustments to account for glare, light changes throughout the day and camera obstructions.	Clean or adjust cameras, Possible recollection if needed.

SECTION 5 QUALITY TEAM ROLES AND RESPONSIBILITIES

The following identifies the quality-related responsibilities of the data collection team and lists specific quality responsibilities.

Team Role	Quality Management Responsibilities
Roadway Asset Management Engineer	• Assess effectiveness of QM procedures • Approve resolution of quality issues • Recommend improvements to quality processes • Communicate weekly with data collection team • Establish reference values for the data collection team • Monitor major event schedule adherence
Assistant Roadway Asset Management Engineer	• Monitor resolution of quality exceptions reported to and from the data collection team • Monitor deliverables for anomalies • Assure training plan addresses all personnel skill levels • Assure correction of all quality issues and changes in procedures as needed • Perform and document final deliverables quality review • Compile documentation of all QC activates
Highway Pavement Management Coordinator	• Assure deliverables meet broad set of data quality standards • Communicate more than weekly with data collection team • Assure quality issue resolution and report results to section leader • Perform data acceptance checks and document results • Schedule and conduct visual rating survey training
Data Collection Supervisor	• Approve each deliverable per quality standards • Assure practice of QC measures in QM plan • Assure proper protocols are used • Assure performance of all quality audits and reporting of all quality exceptions using QC log • Assure and document initial equipment configuration, calibration and verification • Supervise and document the use of vendor recommended test sections
Data Collection Field Team	• Perform daily equipment startup checks, inspections, and calibrations • Perform daily review of data logs and picture quality • Assure real-time monitoring of data and picture quality • Assure performance of weekly control, verification, and blind site testing • Assure documentation of all field QM activities and reporting of any problems by using a QC log
Distress Rating Team	• Perform and document initial rater training and ensure raters are adequately trained in protocols • Perform and document quality audits, including intra and inter-rating checks, report any problems using QC log • Perform retraining as needed

SECTION 6 QUALITY REPORTING PLAN

The Data Collection Supervisor is responsible for day to day operation of DCVs and overall accuracy of data. Roads traveled and miles collected are logged each day and quality monitored regularly through post-collection processing by the Data Quality Manager. Any mistakes are promptly addressed and corrected on an on-going basis.

The data collection team reports to the Highway Pavement Management Coordinator and are regularly appraised of status and any problems during collection. Serving as our main point of contact to the rest of the division, all requests for data or additional collection flow through them. The team stays in regular contact with the vendor for technical and mechanical help on the DCVs sensors, computers, and cameras. In addition, all staff involved regularly undergo continual training and testing on safe operation of DCVs and accurate visual ratings.

All DCVs operators keep detailed notes in dedicated notebooks to ensure proper recordkeeping and make note of problems in the field. These records and concerns are also noted in daily reports to the supervisors. Regular meetings are held at the start of each week to discuss any problems and agenda.

Upon completion of the annual collection, all data is examined again for accuracy and completeness. Data and images are pushed to the server and tested by staff before release. The Assistant Roadway Asset Management Engineer will review all data and distribute updated data to staff, departments, and outside parties as required after approval. Wrap-up meeting is held to discuss collection from the year and how to improve accuracy in future years.

All data collected is reporting to the Highway Performance Monitoring System (HPMS) and summarized for NDOT's pavement sections for use in NDOT's Pavement Management System (PMS).

SECTION 7 AGENCY DATA QUALITY MANAGEMENT PLAN ACCEPTANCE

Data Quality Management Plan accepted by Roadway Asset Management Engineer:

_____ Date: _____
Mark Osborn, PE
Roadway Asset Management Engineer

Data Quality Management Plan accepted by M&R Division Engineer:

_____ Date: _____
Mick Syslo, PE
Materials & Research Division Engineer

Data Quality Management Plan accepted by FHWA Division Administrator:

_____ Date: _____
Joseph Werning, PE
FHWA Nebraska Division Administrator